RESEARCH PLAN

ON

ENERGY EFFICIENT ROUTING IN AD-HOC SENSOR NETWORKS

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In wireless sensor network (WSN), various routing protocols have been proposed to enhance the lifetime of network. WSN is applicable in various scenarios like environment monitoring, agricultural monitoring, military, security, patient monitoring etc. Deployment of nodes (random or manual) and routing protocol for data transfer (flat, hierarchical or location based) both are application specific. So, an application specific approach is good for deployment of nodes as well as for data routing.

In this work, WSN was applied to environment monitoring. In environment or habitat monitoring [1] sensors are used to study vegetation response to climatic trends and diseases, and acoustic and imaging sensors can identify, track, and measure the population of birds and other species. The routing strategy can then be used to route data to a central collection points. Environmental data collection applications typically use tree-based routing topologies where each routing tree is rooted at high-capability nodes that sink data. Data is periodically transmitted from child node to parent node up the tree-structure until it reaches the sink. With tree-based data collection each node is responsible for forwarding the data of all its descendants. Nodes with a large number of descendants transmit significantly more data than leaf nodes. These nodes can quickly become energy bottlenecks [2, 3]. To avoid that, a periodic rotation is necessary to balance the energy consumption of the network. Hierarchical routing, which is a tree-based routing with rotating parent nodes to maximize the network lifetime. The main idea in this class of protocols is that every sensor node within a WSN is grouped along with some other of its neighboring nodes so that to constitute a specific cluster. Data collected by the sensor nodes belonging to a cluster are not directly transmitted to the base station. Instead, a node of the cluster, called cluster head, collects these data and forwards them to the base station after possibly having performed an appropriate data aggregation. In this way, the number of transmitted messages to the base station is reduced and considerable power conservation is achieved. Various routing protocols like Low Energy Adaptive Clustering Hierarchy (LEACH) [4], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [5], TEEN [6], and APTEEN [7] etc. in hierarchical routing technique have been proposed.

Low Energy Adaptive Clustering Hierarchy [4] is one of the first hierarchical routing protocols for sensor network. LEACH is an energy conserving communication protocol where all the nodes in the network are uniform and energy constrained. The nodes organize themselves

into local clusters, with one node acting as the randomly selected local cluster head. LEACH includes random alternation of the high-energy cluster head nodes to enable the sensors to uniformly sustain the power. These cluster head nodes relay their status to the other sensors in the network. Each sensor node resolves which cluster to follow by choosing the cluster head that requires the minimum communication energy.

S. Lindsey et. al. [5] proposed a protocol, called Power Efficient Gathering in Sensor Information Systems (PEGASIS), which was enhanced over LEACH protocol. This protocol is a near optimal chain-based protocol. In PEGASIS, each sensor node forms a pattern so that each node will receive from and transmit to a close neighbor. Each node takes turn being the leader for transmission to the base station so that the average energy spent by each node per round is reduced. Hierarchical-PEGASIS is an extension to PEGASIS, which decreases the delay during transmission from the designated node to the sink. In order to improve the performance by reducing the delay in PEGASIS, messages are transmitted simultaneously. The IEEPB is specially intended for the delay-tolerant applications but the proposed method is also useful for the delay-intolerant applications. It causes tolerable delay in data delivery due to small chains, consisting of fewer numbers of sensors. The multi-chain concept at one hand, decreases the network overhead due to fewer numbers of nodes in chains, whereas on the other hand shrinks the distance between the connected nodes due to their uniform random distribution. Sink mobility alleviates the load on the nodes of chain closer to sink by using the idea of secondary chain heads. The conception of multi-head in the chains diminishes the delay in data delivery and the load on the single chain leader as in IEEPB [8]. In [9], the authors recommended a multi-chain model of PEGASIS along with induction of sink mobility to maximize the network lifetime. Author's considerations are supportive in diminishing the delay in data delivery and distances between the connected nodes through smaller chains. Sink mobility not only lessens the load on the chain leaders in starting rounds, but also reduces the stress on the sparse nodes at the end of network lifetime. The authors also proposed an algorithm for fixed path sink mobility in the model. Sink mobility has major advantages on static sink in enhancing the network lifetime. As for future directions, we are striving to get much better sink mobility specifically toward chain leaders of chains in WSN.

Wireless body area network (WBAN) consists of low-power devices that are placed on, in or near the body of human beings. They are placed to monitor physiological signals and motion for applications [10]. Fig.1. shows deployment of nodes on human body for healthcare applications. Nodes can be put on or around human body to check diseases related to age and get benefit by monitoring these signals [11]. It can be helpful in remote areas for diagnosis of diseases. For health monitoring sensor nodes are positioned on the human body or fixed in the body to monitor essential signs like glucose level, blood pressure, heart rate, body temperature etc. To observe health parameters like heart rate, glucose level etc., and WBAN technology considerably reduces the expenses of patient in a medical care or hospital. Patients can be easily monitored at home. Sensor nodes will constantly sense the data and forward the data to medical server through base station. In WBAN, sensor nodes are equipped with limited battery device and recharging these batteries is a major issue in WBAN. So, it is necessary to make use of minimum energy for transmitting data from sensor nodes to base station. So, an efficient and reliable routing protocol is required for transmission of data. Many energy efficient as well as reliable routing strategies or protocols for WBAN or WSN are proposed in [10-12].

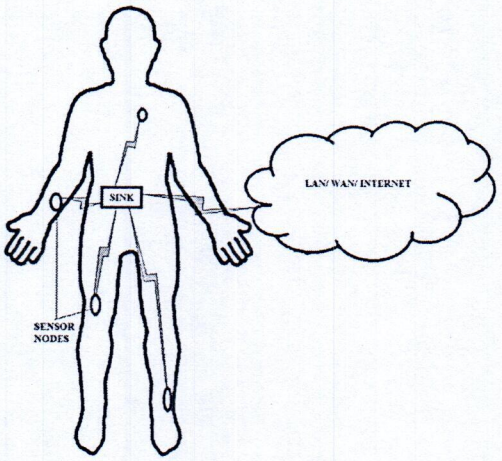

Fig. 1: Deployment of nodes in body (redrawn from [1])

In [11], the author proposed a routing algorithm for WBASNs known as M-ATTEMPT. In M-ATTEMPT protocol, direct communication i.e. data will directly transmitted to base station, as well as multi-hop communication i.e. data will transmitted through multiple nodes to base station, is used for routing. In [12], the authors proposed a novel mechanism for data transfer

known as cost function to route data in WBAN. Cost function is calculated based on the remaining energy of nodes and their distance from sink. The parent nodes are selected based on the minimum value of cost function. Other nodes forward their data to parent node as a children. Nodes used for ECG and Glucose monitoring forward their data to sink directly. A routing protocol that follows store and forward mechanism to increase the reliability of data packet is proposed. Each sensor node has capability of storing the data packet and transmitting it to next node. But for storing and then retransmitting it causes more energy consumption and delay in transferring of packets. Fatme El-Moukaddem et. al. [13] proposed a method of mobile node rotation. They rotate the nodes through the high power consumption locations to low power consumption areas to maximize the network lifetime. Mohammed Abo-Zahhad et. al. [15] proposed a mobile sink-based adaptive immune energy-efficient clustering protocol (MSIEEP) to alleviate the energy holes. A MSIEEP uses the adaptive immune algorithm (AIA) to guide the mobile sink-based on minimizing the total dissipated energy in communication and overhead control packets. Moreover, AIA is used to find the optimum number of cluster heads (CHs) to improve the lifetime and stability period of the network. In paper [15], a Priority based Energy Aware (PEA) routing protocol is proposed. In this algorithm, child nodes choose a parent node connected to sink based on a cost function that depends upon priority, residual energy and distance of node. Residual energy facilitates load balancing i.e. selection of different nodes for transmission. Distance helps in successful packet delivery to the parent node and caters for body postures. Priority helps to select a best possible path to forward the critical data keeping in view the energy constraint in WBANs.

Future Scope

Energy efficiency is the most important issue for wireless sensor networks (WSN) since sensor nodes have limited batteries. Sensors measure and monitor ambient conditions in the surrounding environment such as heat, pressure, vibration, presence of objects, etc. The measurements and monitored events are then forwarded towards a static sink. Replacing the batteries of sensor nodes is likely to require significant effort; therefore, WSNs have to be able to operate without human intervention for an adequately long time.

Direct transmission to sink does not guarantee well balanced distribution of the energy load among sensors of the network. Thus, many clustering protocols have been specifically designed for WSNs to improve data aggregation mechanisms, balance distribution of the energy load among sensors in WSN and thus increase the network lifetime. These protocols widely vary depending on the nodes deployment, the network and radio models, and the network architecture. The problem of these protocols is using static sinks. Moreover, the sensor nodes near the static sink act as relays for sensors that are far from it and thus will deplete their energy very quickly, resulting energy holes in the sensor field. The energy hole problem leads to a premature disconnection of the network and thus sink gets isolated from the rest of the network due to the death of its neighbors, while most of the sensor nodes are still alive and fully operational. Exploiting the mobility of the sink has been widely accepted as an efficient way to alleviate the energy hole problem in WSNs and further prolong the network lifetime by avoiding excessive transmission overhead at nodes that are close to the sink.

An important challenge in WBANs is the movement human body. Human body frequently changes its posture and is not static for long time. Therefore, while devising a routing strategy it is important to cater for the posture change of body without affecting the overall communication process.

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